CLAIMS

1. A synchronous motor which comprises:

a stator including a stator iron core having a winding wound therearound, said stator iron core having an inner cylindrical surface;

a rotor including a rotor iron core and rotatably accommodated while facing the inner cylindrical surface of the stator iron core, said rotor including a plurality of conductor bars accommodated within corresponding slots defined in an outer peripheral portion of the rotor iron core, said conductor bars having their opposite ends shortcircuited by respective shortcircuit rings to form a starter squirrel cage conductor, said rotor having a plurality of magnet retaining slots defined therein at a location on an inner side of the conductor bars; and

permanent magnets embedded within the magnet retaining holes in the rotor and defining rotor magnetic poles;

the neighboring members of the slots being spaced a distance which is referred to as a slot interval, the slot interval at a location adjacent one end of rotor magnetic poles being smaller than the slot interval at a location adjacent a center point of the rotor magnetic poles.

2. The synchronous motor as claimed in Claim 1, wherein the slot interval at a location spaced from the center point of the rotor magnetic poles in a direction conforming to a direction of rotation of the rotor is chosen to be greater than the slot interval at a location spaced from the center point of the rotor magnetic poles in a direction counter to the direction of rotation of the rotor.

3. A synchronous motor which comprises:

a stator including a stator iron core having a winding wound therearound, said stator iron core having an inner cylindrical surface;

a rotor including a rotor iron core and rotatably accommodated while facing the inner cylindrical surface of the stator iron core, said rotor including a

plurality of conductor bars accommodated within corresponding slots defined in an outer peripheral portion of the rotor iron core, said conductor bars having their opposite ends shortcircuited by respective shortcircuit rings to form a starter squirrel cage conductor, said rotor having a plurality of magnet retaining slots defined therein at a location on an inner side of the conductor bars; and

permanent magnets embedded within the magnet retaining holes in the rotor and defining rotor magnetic poles;

said slots having a radial length that is smaller at a center point of the rotor magnetic poles; and

a distance between one of the slots positioned adjacent one end of the rotor magnetic poles and the magnet retaining holes being smaller than a distance between the slots positioned at other locations of the rotor and the magnet retaining holes.

4. The asynchronous motor as claimed in claim 3, wherein the distance between the slots in the rotor iron core and the magnet retaining holes progressively increases from a position adjacent one end of the rotor magnetic poles towards a position adjacent the center point of the rotor magnetic poles.

5. A synchronous motor which comprises:

a stator including a stator iron core having two-pole windings wound therearound, said stator iron core having an inner cylindrical surface;

a rotor including a rotor iron core and rotatably accommodated while facing the inner cylindrical surface of the stator iron core, said rotor including a plurality of conductor bars positioned adjacent an outer periphery of the rotor iron core, and shortcircuit rings positioned at axially opposite ends of the rotor iron core, said conductor bars and shortcircuit rings being integrally molded together by means of an aluminum die casting to form a starter squirrel cage conductor, said rotor having a plurality of magnet retaining slots defined therein at a location on an inner side of the conductor bars; and

permanent magnets embedded within the magnet retaining holes in the rotor and defining two magnetic poles of different polarities;

said shortcircuit rings having an inner diameter positioned outside the associated magnet retaining holes, the inner diameter of the shortcircuit rings at a location adjacent one end of the magnetic poles being chosen to be greater than an inner diametric dimension at a location adjacent the point intermediate of the magnetic poles.

6. The synchronous motor as claimed in Claim 5, wherein the inner diameter of the shortcircuit rings on one side where the permanent magnets are inserted lies outside the magnet retaining holes in the rotor iron core;

wherein the inner diametric dimension of one of the shortcircuit rings adjacent one end of the magnetic poles is chosen to be greater than the inner diametric dimension thereof adjacent the point intermediate of the magnetic poles; and

wherein the inner diametric dimension of the other of the shortcircuit rings lies inwardly of the whole or a part of the magnet retaining holes; and

further comprising an end plate made of a non-magnetizable plate and positioned between such other shortcircuit ring and the rotor iron core so as to cover the magnet retaining holes.

7. The synchronous motor as claimed in Claim 5, wherein the inner diameter of the shortcircuit rings on one side where the permanent magnets are inserted lies outside the magnet retaining holes in the rotor iron core;

wherein the inner diametric dimension of one of the shortcircuit rings adjacent one end of the magnetic poles is chosen to be greater than the inner diametric dimension thereof adjacent the point intermediate of the magnetic poles; and

wherein the inner diametric dimension of the other of the shortcircuit rings lies inwardly of the whole or a part of the magnet retaining holes; and

further comprising one or a plurality of electromagnetic steel plates of the rotor iron core adjacent the other shortcircuit ring, which is or are not formed with the magnet retaining holes.

8. The synchronous motor as claimed in Claim 5, wherein the inner diameter of the shortcircuit rings on one side where the permanent magnets are inserted is of a shape lying along the magnet retaining holes in the rotor iron core.

9. The synchronous motor as claimed in Claim 5, wherein the stator iron core is made up of a stator laminate of electromagnetic steel plates and the rotor iron core is also made up of a rotor laminate of electromagnetic steel plates, said stator laminate having a thickness about equal to that of the rotor laminate.

10. A synchronous motor which comprises:

a stator including a stator iron core having a winding wound therearound, said stator iron core having an inner cylindrical surface;

a rotor including a rotor iron core in the form of a rotor laminate of a plurality of electromagnetic steel plates and rotatably accommodated while facing the inner cylindrical surface of the stator iron core, said rotor iron core including a magnet retaining portion provided with magnet retaining slots, a magnetic flux shortcircuit preventive portion coupled with the magnet retaining portion and provided with magnetic flux shortcircuit preventive holes communicated with the magnet retaining holes, and a rotor outer end portion coupled with the magnetic flux shortcircuit preventive portion and provided with holes communicated with the magnetic flux shortcircuit preventive holes; and

permanent magnets embedded within the magnet retaining holes in the rotor and defining rotor magnetic poles;

said magnetic flux shortcircuit preventive holes being smaller than the magnet retaining holes such that by allowing the permanent magnets to be held

in engagement with outer edges of the magnetic flux shortcircuit preventive holes, the permanent magnets are axially positioned.

11. A synchronous motor which comprises:

a stator including a stator iron core having a winding wound therearound, said stator iron core having an inner cylindrical surface;

a rotor including a rotor iron core in the form of a rotor laminate of a plurality of iron plates and rotatably accommodated while facing the inner cylindrical surface of the stator iron core, said rotor iron core including a magnet retaining portion provided with magnet retaining slots, and a permanent magnet support portion coupled with the magnet retaining portion and closing the magnet retaining holes; and

permanent magnets embedded within the magnet retaining holes in the rotor and defining rotor magnetic poles;

the permanent magnets being axially positioned by means of the permanent magnet support portion.

12. The synchronous motor as claimed in Claim 11, further comprising a rotor iron core outer end coupled with the permanent magnet support portion and provided with hole positioned axially of the magnet retaining holes.

13. The synchronous motor as claimed in Claim 10 or 11, further comprising a starter squirrel cage conductor in the rotor iron core.

14. A synchronous motor which comprises:

a stator including a stator iron core having a winding wound therearound, said stator iron core having an inner cylindrical surface;

a rotor including a rotor iron core and rotatably accommodated while facing the inner cylindrical surface of the stator iron core, said rotor including a plurality of conductor bars positioned adjacent an outer periphery of the rotor iron core and shortcircuit rings positioned at axially opposite ends of the rotor iron core, said conductor bars and said shortcircuit rings being integrally molded

together by means of an aluminum die casting to form a starter squirrel cage conductor, said rotor iron core having a plurality of magnet retaining holes defined therein; and

permanent magnets embedded within the magnet retaining holes at a location on an inner side of the conductor bars, said magnet retaining holes having a width in a radial direction of the rotor iron core being greater at a location adjacent one end of the axial direction of the rotor than at a location inwardly of an axial direction of the rotor.

15. The synchronous motor as claimed in Claim 14, wherein the width of the magnet retaining holes in the radial direction is smaller at a location inwardly of the axial direction of the rotor than at opposite ends of the axial direction of the rotor and further comprising an electromagnetic steel plate provided outside one of the opposite ends of the axial direction of the rotor for closing the magnet retaining holes.

16. The synchronous motor as claimed in Claim 14, wherein the width of the magnet retaining holes in the radial direction is greater at one of opposite ends of the axial direction of the rotor than at a location inwardly of the axial direction of the rotor and wherein the other of the opposite ends of the axial direction of the rotor is not provided with any magnet retaining holes for closing the magnet retaining holes at a location inwardly of the axial direction of the rotor.

17. A synchronous motor which comprises:

a stator including a stator iron core having a winding wound therearound, said stator iron core having an inner cylindrical surface;

a rotor including a rotor iron core and rotatably accommodated while facing the inner cylindrical surface of the stator iron core, said rotor including a plurality of conductor bars positioned adjacent an outer periphery of the rotor iron core and shortcircuit rings positioned at axially opposite ends of the rotor

iron core, said conductor bars and said shortcircuit rings being integrally molded together by means of an aluminum die casting to form a starter squirrel cage conductor, said rotor iron core having a plurality of magnet retaining holes defined therein; and

permanent magnets embedded within the magnet retaining holes at a location on an inner side of the conductor bars;

the rotor iron core being in the form of a laminate of electromagnetic steel plates and including an entwining portion provided adjacent the magnet retaining holes for lamination of the electromagnetic steel plates, wherein the magnet retaining holes adjacent the entwining portion has a width in a radial direction thereof which is partially enlarged in a direction towards the entwining portion.

18. A synchronous motor which comprises:

a stator including a stator iron core having a winding wound therearound, said stator iron core having an inner cylindrical surface;

a rotor including a rotor iron core and rotatably accommodated while facing the inner cylindrical surface of the stator iron core, said rotor including a plurality of conductor bars positioned adjacent an outer periphery of the rotor iron core and shortcircuit rings positioned at axially opposite ends of the rotor iron core, said conductor bars and said shortcircuit rings being integrally molded together by means of an aluminum die casting to form a starter squirrel cage conductor, said rotor iron core having a plurality of magnet retaining holes defined therein; and

permanent magnets embedded within the magnet retaining holes at a location on an inner side of the conductor bars;

said rotor iron core having conductor bar holes defined therein in an axial direction thereof and positioned inwardly of the magnet retaining holes, said conductor bar holes being filled up by the aluminum die casting simultaneously

with the starter squirrel cage conductor, said conductor bars protruding a distance outwardly from an axial end of the rotor iron core to form respective projections for securement of an end plate, said end plate being made of a non-magnetizable material and secured fixedly to the end of the rotor iron core.

19. The synchronous motor as claimed in Claim 18, wherein the end plate disposed at the axial end of the rotor iron core is partly or wholly covered by the corresponding shortcircuit ring.

20. The synchronous motor as claimed in Claim 18, wherein the end plate covered by the shortcircuit ring is provided with projections engageable in respective holes in the rotor iron core.

21. The synchronous motor as claimed in Claim 18, wherein one or a plurality of electromagnetic steel plates at one axial end of the rotor iron core is or are not provided with any magnet retaining hole.

22. The synchronous motor as claimed in Claim 19, wherein at a location where the electromagnetic steel plates not provided with any magnet retaining holes contact the permanent magnets, there is provided projections protruding towards the permanent magnets.

23. A synchronous motor which comprises:

a stator including a stator iron core having a winding wound therearound, said stator iron core having an inner cylindrical surface;

a rotor including a rotor iron core and rotatably accommodated while facing the inner cylindrical surface of the stator iron core, said rotor including a plurality of conductor bars positioned adjacent an outer periphery of the rotor iron core and shortcircuit rings positioned at axially opposite ends of the rotor iron core, said conductor bars and said shortcircuit rings being integrally molded together by means of an aluminum die casting to form a starter squirrel cage conductor, said rotor iron core having a plurality of magnet retaining holes defined therein, one of the shortcircuit rings having an inner periphery formed

with recesses;

permanent magnets embedded within the magnet retaining holes at a location on an inner side of the conductor bars; and

an end plate made of a non-magnetizable material and having an outer periphery formed with projections complemental in shape to the recesses in the shortcircuit ring, a peripheral portion of each of the recesses in the shortcircuit ring being axially pressed to deform to thereby secure the end plate to an axial end of the rotor iron core with the projections in the end plate received in the corresponding recesses in the shortcircuit ring.

24. A synchronous motor which comprises:

a stator including a stator iron core having a winding wound therearound, said stator iron core having an inner cylindrical surface;

a rotor including a rotor iron core and rotatably accommodated while facing the inner cylindrical surface of the stator iron core, said rotor including a plurality of conductor bars positioned adjacent an outer periphery of the rotor iron core and shortcircuit rings positioned at axially opposite ends of the rotor iron core, said conductor bars and said shortcircuit rings being integrally molded together by means of an aluminum die casting to form a starter squirrel cage conductor, said rotor iron core having a plurality of magnet retaining holes defined therein;

permanent magnets embedded within the magnet retaining holes at a location on an inner side of the conductor bars;

said magnet retaining holes being of a design allowing the permanent magnets, when embedded therein so as to be butted end-to-end in a generally V-shaped configuration to form a single magnetic pole, and having an air space defined between one end face of the permanent magnet and an inner face of one end of the magnet retaining hole for preventing shortcircuit of magnetic fluxes, a barrier slot for preventing shortcircuit of magnetic fluxes being defined

between the magnet retaining holes for accommodating the neighboring permanent magnets of different polarities, a first bridge portion being provided between the magnet retaining hole and the barrier slot so as to sandwich the barrier slot, and a second bridge portion being provided between the neighboring permanent magnets of the same polarity and the corresponding magnet retaining holes, said second bridge portion being narrow at a location adjacent a center of the rotor and large at a location adjacent an outer periphery of the rotor.

25. A synchronous motor which comprises:

a stator including a stator iron core having a winding wound therearound, said stator iron core having an inner cylindrical surface;

a rotor including a rotor iron core and rotatably accommodated while facing the inner cylindrical surface of the stator iron core, said rotor including a plurality of conductor bars positioned adjacent an outer periphery of the rotor iron core and shortcircuit rings positioned at axially opposite ends of the rotor iron core, said conductor bars and said shortcircuit rings being integrally molded together by means of an aluminum die casting to form a starter squirrel cage conductor, said rotor iron core having a plurality of magnet retaining holes defined therein;

permanent magnets embedded within the magnet retaining holes at a location on an inner side of the conductor bars to provide two magnetic poles;

said rotor iron core increasing from axially opposite ends thereof towards a point intermediate of the length of the rotor to render it to represent a generally oval shape, the permanent magnets being mounted after formation of the starter squirrel cage conductor by means of the aluminum die casting.

26. A self-starting synchronous motor as claimed in any one of Claims 1 to 25, wherein the permanent magnets are employed in the form of a rare earth magnet.